BMP
Retrofit
Pilot Program

FINAL RESUBMITTAL
February 2000 (Approved)
June 15, 2000 (Revised)

BASIS OF DESIGN REPORT DRAINAGE DESIGN, DISTRICT 7 PS&E,
CONTINUOUS DEFLECTIVE SEPARATORS

Caltrans Report ID #: CTSW-RT-2000-001

Prepared For:

California Department of Transportation
CALTRANS ENVIRONMENTAL PROGRAM
1120 N St., MS 27
Sacramento, CA 95814
P.O. Box 942874, MS 27
Sacramento, CA 94272-0001

Prepared By:

Montgomery Watson - Chaudhary
1230 Columbia St., Suite 750
San Diego, CA 9210

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BMP	Best Management Practice
Caltrans	State of California Department of Transportation
CDS	Continuous Deflective Separation
PS&E	Plans, Specifications and Estimates

1.0 INTRODUCTION

1.1 General

The Storm Water Retrofit Pilot Program will evaluate the removal efficiency for constituents of concern, technical feasibility, and costs of retrofitting California Department of Transportation (Caltrans) facilities with water quality controls. The study will evaluate the effectiveness of a wide range of storm water controls through a comprehensive two year water quality monitoring program. Construction of a number of these devices will allow Caltrans to develop accurate cost estimates for retrofit Best Management Practice (BMP) projects. The costs will be assessed through detailed records kept on the process of designing, building, operating, and maintaining each device.

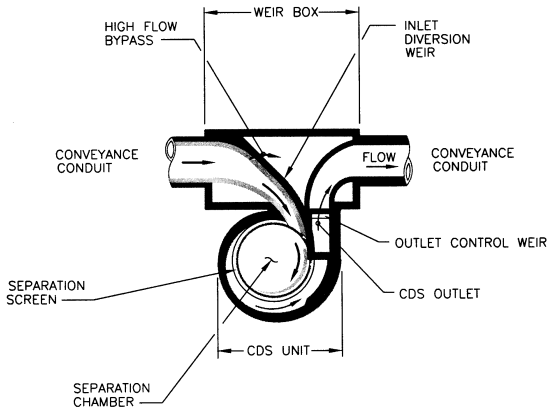
This report documents the appropriate design elements employed in the design of Continuous Deflective Separation (CDS) BMP Facilities at two locations within Caltrans District 7. The content of this report will be confined to documenting the hydrologic characteristics, water quality design parameters and the hydraulic factors considered during the design phase of the program.

The two CDS Facilities presented in this report replace the four Trapping Catchbasin facilities previously designed and presented in *Basis of Design Report, Drainage Design, District 7 Procurement B*. This replacement is a result of a *Statement of Understanding* reached by Caltrans and the plaintiffs on March 2, 1999, and a subsequent Stipulation signed by both parties in July of that year.

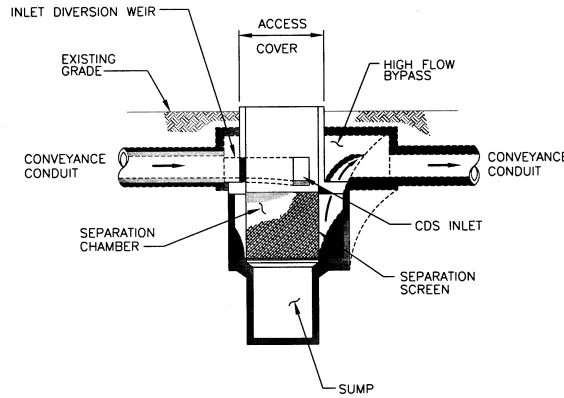
1.2 Objectives

The objective of the design of the two CDS Retrofit Pilot Facilities was to follow, as close as possible, the manufacturer's specifications of the CDS unit, while complying with applicable Caltrans District 7 site-specific requirements. All deviations from the manufacturer's design guidelines will be noted in Section 3 of this report.

As presented by CDS Technologies, Inc., the CDS units are designed as gross pollutant traps which capture sediments and floatables in storm water runoff. The units work by diverting the incoming flow into a pollutant separation chamber and a containment chamber (or sump). Solids within the separation chamber are kept in continuous motion and are prevented from blocking the separation screen. Water passes through the screen and flows downstream. According to the manufacturer, the non-blocking screen ensures that all gross pollutants are retained except for flows that overflow the High Flow Bypass Weir. A generalized illustration of the unit and the operating components is provided below:



PLAN VIEW



ELEVATION

Floating items are kept in continuous motion on the water surface, while heavier materials settle into a containment sump which can be routinely cleaned.

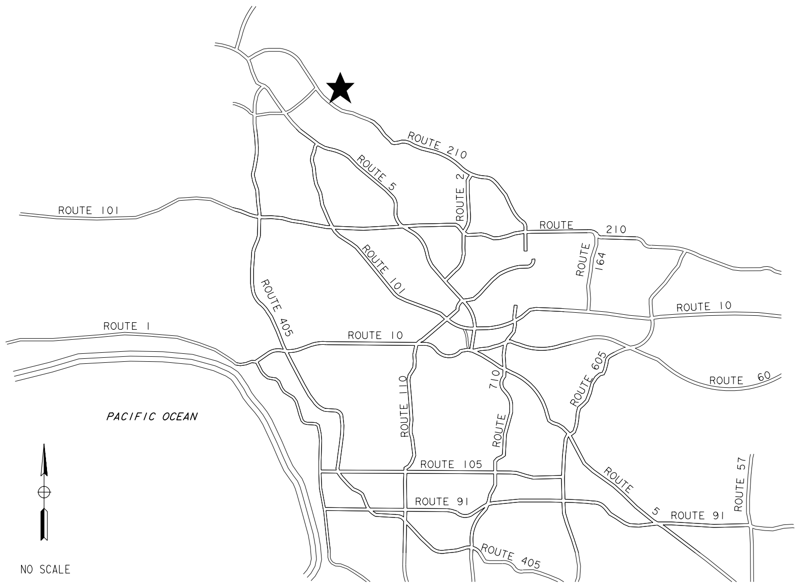
1.3 Project Locations

The two sites for this project are located in the city of Lake View Terrace in Los Angeles County, and are presented in Table 1-1.

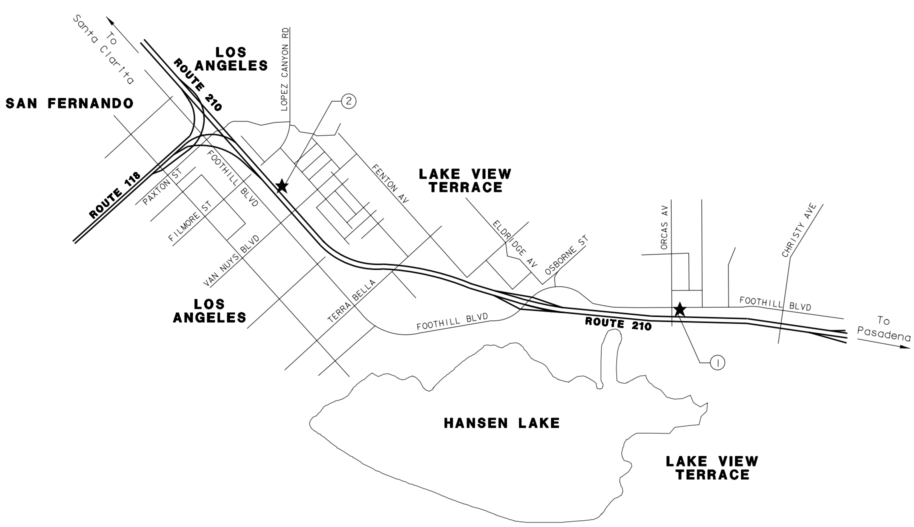
TABLE 1-1
CDS Retrofit Pilot Sites

SITE NO.	BMP LOCATION
1	Adjacent to Westbound I-210 Shoulder, approximately 150 feet east of Orcas Ave. Undercrossing
2	Adjacent to Westbound I-210 Shoulder, approximately 700 feet east of Filmore St.

A vicinity map presenting the general location (with respect to major roadways) and detailed location of each site is presented in Figure 1-1. Both project locations are the same as those identified in Attachment A of the *Stipulation and [Proposed] Order re Agreement re Retrofit Pilot Program*, dated March 2, 1999. As shown, the two pilots are along the same stretch of Route 210 in the city of Lake View Terrace, within approximately 2 miles of each other.



Vicinity Map



Detail Map

CDS PILOT SITES
FIGURE 1-1

1.4 Construction Costs

The preliminary engineer's estimated cost of construction for the two BMP sites is $83,159.50. This estimate is based on quantity of work items extracted from the design, current Caltrans cost data (*1996 Contract Cost Data, Revision No. 1, 8/97*), equipment supplier cost estimates, and engineering judgement. A copy of the Engineer's Estimate is provided in Appendix D. Note that this estimate does not include the following items of construction, as they are being furnished to the contractor by Caltrans:

- Two Precast 1.1 cfs Fiberglass CDS Units
- One 18 inch Fiberglass H-Flume
- One 24 inch Fiberglass H-Flume
- One 18 inch Fiberglass Flume Approach Structure
- One 24 inch Fiberglass Flume Approach Structure

The above list of State-furnished items increases the total construction cost estimate by approximately $35,000.

2.0 HYDROLOGIC CHARACTERISTICS

This section presents the approach and methodology applied in determining the hydrologic characteristics of the two CDS Retrofit Pilots. In accordance with the Storm Water BMP Retrofit Pilot Program guidelines, the hydrologic computations were performed for a 1 year, 24 hour storm and a 25 year storm.

2.1 Rainfall Characteristics (Parameters)

Rainfall characteristics utilized in the design include:

- Intensity (rate of rainfall),
- Duration (time rainfall lasts), and
- Frequency (statistical probability of how often rainfall will occur).

Sources of rainfall data include the Caltrans Average Intensity Duration Curves for District 7; staff at the Los Angeles County Department of Public Works (LACDPW); and the *Scoping Study, Retrofit Pilot Program, Caltrans District 7,* prepared by Robert Bein, William Frost and Associates dated April 28, 1998.

The amount of rainfall from a 1 year, 24 hour storm was estimated by Brown and Caldwell using rain gauge stations within the study area (Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, May 1997). Rainfall values were determined using precipitation records from 1944 to 1995 (24-hour rainfall totals) from the Los Angeles International Airport (LAX) weather station. The data was analyzed using the log-Pearson type III method and by the annual series data method. Also, a second and third set of rainfall records were analyzed from the Van Nuys and the downtown Los Angeles weather stations. Both locations were used to compare with the information gathered from LAX because all of the stations are located in the same rainfall region (coastal plain) as defined by the Los Angeles Department of Public Works (LACDPW).

At the LAX weather station, the calculated 1 year, 24 hour rainfall equaled 0.5-inches (log-Pearson) and 1.12-inches (annual series data method). Two extreme drought years may have influenced the outcome of the log-Pearson analysis. The Van Nuys and downtown Los Angeles stations were 0.71 and 0.73-inches, respectively, using the annual series data method. From the results, the exact size of the 1 year, 24 hour storm event is uncertain. The study concluded that 1 inch of rainfall is slightly greater than what the log-Pearson method estimates, and slightly less than what the annual series method estimates. It was therefore determined that 1.0 inches was a reasonable value for the Los Angeles Coastal Plain (Caltrans Zone K, see Appendix A Hydrology), and was used to design and size each BMP.

2.2 Soil Types and Infiltration

The *Pre-Construction Geotechnical Evaluation Report* provides the following information for the two sites in question:

> *"On site natural materials were found to consist of cobbles and gravels with silty sand to sand matrix. After further evaluation, the site is shown to be built on surficial alluvium deposits or fill. Borings from selected As-Built plans encountered slightly compact to compact brown gravely sand to a maximum depth of approximately 50 feet below the surface. Boulders and cobbles were noted close to the surface. No water was encountered in these borings."*

Given that infiltration is not being employed as a treatment mechanism for these projects, no additional geotechnical exploration or testing was required (or performed) at either site.

2.3 Methodology and Procedure

The estimation of the peak discharge (Q_{peak}) for a recurrence interval of a 1-year and 25-year storm event was calculated using the Rational Method, which computes the discharge as follows:

$$Q_{peak} = 0.28CiA$$

Where:

Q_{peak} = Design discharge in m^3/s
C = Coefficient of runoff
i = Average rainfall intensity in mm/hr for the selected frequency and for the duration equal to the time of concentration (t_c)
A = Drainage area in km^2

The Coefficient of runoff, C, was estimated as follows:

- For the 1 year recurrence interval, it was estimated to be 0.95 for both sites, given that the tributary area for both sites is paved roadway.
- For the 25 year recurrence interval, it was estimated to be 1.0 for both sites. This value was computed in accordance with the guidelines presented in the Caltrans Highway Design Manual, which states that infiltration, detention, and other losses have a proportionally smaller effect during less frequent, higher intensity storms. As given in the manual, this effect was accounted for by multiplying the runoff coefficient by a frequency factor of 1.1. The resulting product, being greater than 1.0 (0.95 times 1.1

equals 1.045) was replaced with a value of 1.0 (as specified in the manual).

The average rainfall intensity (i) is a function of the time of concentration (t_c), and the rainfall zone in which the BMP is located. The time of concentration is defined as the time required for storm runoff to travel from the most remote point of the drainage basin to the point of interest. As given in the Caltrans Highway Design Manual, time of concentrations were calculated using the following equation:

$$t_c = \frac{3.3(1.1 - C)(L)^{1/2}}{[S(100)]^{1/3}}$$

Where:

t_c = time of concentration in minutes
C = Coefficient of runoff
L = Overland travel distance in meters
S = Slope in m/m

The computed time of concentration was compared to the minimum value of 10 minutes as specified in the Caltrans Highway Design Manual. A value of 10 minutes was used for subsequent rainfall intensity calculations if the computed time of concentration was less than 10 minutes.

The resulting rainfall intensities were estimated as follows:

- For the 1 year recurrence interval, the intensities were provided by LACDPW. This source was utilized given that Caltrans does not provide Intensity-Duration-Frequency (IDF) curves for the 1 yr, 24-hr recurrence interval.
- For the 25 year recurrence interval, Caltrans IDF curves were utilized.

2.4 Summary of Results

The hydrologic results for the 1 year and 25 year recurrence intervals for the two pilot sites are presented in Tables 2-1 and 2-2, respectively.

TABLE 2-1
HYDROLOGIC CHARACTERISTICS – 1 YEAR

Site No.	BMP Location	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)	Drain. Area (m^2)	Rainfall Intensity (in/hr)	Q_{peak} (m^3/s)
1	I-210 East of Orcas Ave.	0.95	1	130	5.6	4,416	0.24	0.007
2	I-210 East of Filmore St.	0.95	3	280	5.7	10,200	0.24	0.017

TABLE 2-2
HYDROLOGIC CHARACTERISTICS – 25 YEAR

Site No.	BMP Location	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)	Drain. Area (m^2)	Rainfall Intensity (in/hr)	Q_{peak} (m^3/s)
1	I-210 East of Orcas Ave.	1.0	1	130	3.8	4,416	2.9	0.09
2	I-210 East of Filmore St.	1.0	3	280	3.8	10,200	2.9	0.21

3.0 WATER QUALITY DESIGN DISCUSSION AND ASSUMPTIONS

Technical references used for the design of the CDS Pilots include the following:

- *CDS Technical Manual,* CDS Technologies, Inc., 1999.
- *Caltrans Highway Design Manual,* California Department of Transportation, 1997.
- *Caltrans Storm Water Quality Handbook, Planning and Design Staff Guide,* California Department of Transportation, 1997.
- *BMP Retrofit Pilot Program, Composite Siting Study, District 7,* Robert Bein, William Frost and Associates, 1998.
- *Scoping Study, Retrofit Pilot Program, Caltrans District 7,* Robert Bein, William Frost and Associates, April 1998.

In addition, the design is based on the following criteria agreed upon by Caltrans staff, Consultant staff, and CDS Technologies, Inc. staff during a site review on March 12, 1999:

- A single H-Flume, located downstream of the CDS unit will be employed. The upstream sampler will be triggered by the downstream flume.
- A flume setup similar to the setup used at the I-105/I-710 litter management sites (in which a Fiberglass approach section is used, and is mounted on a unistrut frame) is preferred.
- The CDS unit requires uniform flow, and energy dissipation upstream of the CDS unit will be provided by a CMP Tee.
- The runoff will be intercepted from the existing CMP pipe along the embankment, at an appropriate location to provide the necessary elevation differential. No headwall will be constructed.
- The BMP facilities will be supported with fill material instead of a raised platform.
- The CDS unit will include a debris basket (provided by CDS Technologies, Inc.), which will facilitate debris removal and sump cleaning.
- The debris basket will include a 50 micron mesh fabric liner (provided by CDS Technologies, Inc.), thereby retaining all particles greater than 50 micron in size. This is relatively new option offered by the manufacturer which is not presently included in the product specifications.
- The CDS unit include a 1200 micron screen (provided by CDS Technologies, Inc.), which is the smallest screen currently offered by CDS Technologies, Inc.
- A Davit will be used to facilitate removal of the debris basket. This item is not sold by CDS Technologies, but the manufacturer will provide a product recommendation.
- A mesh bag, similar to those used at the Caltrans Litter Management BMP sites, will be installed between the CDS unit and the downstream flume to collect any debris which bypasses the CDS unit.

- The CDS unit will not include oil sorbent material for removal of oil and grease. The manufacturer believes that the expected amount of oil and grease from the roadway is minimal, and does not warrant the cost of utilizing the oil sorbent material.
- The weir in the CDS units will be set (by the manufacturer prior to delivery) such that the full capacity of the CDS units will be utilized (thereby treating up to 1.1 cfs), instead of setting it to treat only the expected Water Quality Discharge (0.25 cfs at I-210 East of Orcas and 0.58 cfs at I-210 East of Filmore).

Site specific issues are presented in the following sections.

3.1 Site 1, I-210 East of Orcas Ave.

This location is approximately 50 meters east of the Orcas Ave. undercrossing along Route I-210. The BMP location is at the bottom of the embankment, between the Roadway Toe-of-Slope and the Caltrans Right-of-Way fence.

3.2.1 Design Summary

The BMP Facility at this site will be constructed in-line with the existing concrete channel, such that the effluent from the BMP will discharge directly into the channel. The BMP facility will start slightly up the embankment in order to provide sufficient elevation differential across the BMP and still have the effluent discharge into the channel under free-fall conditions.

The Fiberglass H-flume and approach section will be installed above a concrete pad supported by a unistrut frame. This provides plenty of flexibility when setting the flow lines.

The facility will be within a fenced area to reduce the chance of vandalism and/or theft of the equipment.

A 457 mm (18 inch) H-Flume will be used to monitor the flow. This size flume was selected because it has an operating range of 0.0057 cfs to 5.42 cfs, and the expected range of flows for this site is between 0.25 cfs (for the 1 year event) and 3.2 cfs (for the 25 year event).

3.2.2 Tributary Drainage Area

The tributary drainage area associated with this site is equal to 4,416 square meters (1.1 acres), and is composed entirely of runoff from a 190 meter long section of the Westbound lanes of the I-210 Roadway. The runoff is collected by four drain inlets located approximately 62 meters apart along the Westbound I-210 shoulder, which discharge the runoff through a single outfall at the bottom of the embankment

The tributary area is bounded by the western-most drain inlet, a high point in the roadway 190 meters to the east, and the concrete barrier separating the eastbound and westbound roadway lanes.

3.2.3 Siting Constraints

The siting constraints at this site were as follows:

- The distance between the Toe-of-Slope and the Right-of-Way fence is only 4 meters. As a result, the BMP facility was placed along the center line of the existing concrete ditch, thereby requiring the removal of 4.5 meters of ditch. A new concrete ditch will be constructed parallel to the facility, between the facility and the Right-of-Way fence, allowing proper drainage of surrounding runoff.

- The BMP is located 24 meters away from an existing Chain Link Fence, in a landscaped area. Site access will be provided by installing a 3 meter wide Chain Link Gate in the existing fence and constructing a gravel road between the gate and the BMP.

- There is not enough fall in elevation between the flow line of the existing outfall and the BMP effluent discharge point to enable the BMP to start at the existing flow line and have a free fall effluent discharge into the concrete ditch (i.e., the discharge would be below grade). To correct for this, the runoff will be intercepted slightly up the embankment, providing the necessary elevation differential across the BMP.

- An existing 75 mm PVC drain pipe discharges runoff from an adjacent private property into the existing Tee at the bottom of the outfall. This pipe will be modified such that it discharges into the new parallel ditch.

- Security of the equipment is a concern at this site. As a result, Chain Link Fence with Barbed Wire will be installed around the perimeter of the BMP facility.

- There are no available sources of power to provide electricity for refrigerated samplers. Therefore, deep cell marine batteries will be used.

3.2 Site 2, I-210 East of Filmore St.

This location is approximately 220 meters east of Filmore Street along Route I-210. The BMP location is at the bottom of the embankment, between the Roadway Toe-of-Slope and the Caltrans Right-of-Way fence.

3.3.1 Design Summary

The BMP Facility at this site will be constructed parallel to the existing concrete channel, and the effluent from the BMP will discharge into the channel via a concrete apron. The apron will include grouted rip-rap for energy dissipation. The BMP facility will start slightly up the embankment in order to provide sufficient elevation differential across the BMP and still have the effluent discharge into the channel under free-fall conditions.

The Fiberglass H-flume and approach section will be installed above a concrete pad supported by a unistrut frame. This provides plenty of flexibility when setting the flow lines.

The facility will be within a fenced area to reduce the chance of vandalism and/or theft of the equipment.

A 610 mm (24 inch) H-Flume will be used to monitor the flow. This size flume was selected because it has an operating range of 0.0073 cfs to 11.1 cfs, and the expected range of flows for this site is between 0.58 cfs (for the 1 year event) and 7.4 cfs (for the 25 year event).

3.3.2 Tributary Drainage Area

The tributary drainage area associated with this site is equal to 10,200 square meters (2.5 acres), and is composed of runoff from a 250 meter long section of the Westbound I-210 / Westbound SR-118 Connector Road, a 110 meter long section of the Westbound lanes of the I-210 Roadway, a 90 meter long section of the Eastbound lanes of the I-210 Roadway, and a 90 meter long section of the Eastbound SR-118 / Eastbound I-210 Connector Road. The runoff is collected by:

- Five drain inlets located approximately 62 meters apart along the Westbound I-210 / Westbound SR-118 Connector Road shoulder.
- One drain inlet located along the Eastbound I-210 Roadway shoulder (which discharges into one of the five Westbound I-210 / Westbound SR-118 drain inlets).

- One drain inlet located along the Eastbound SR-118 / Eastbound I-210 Connector Road shoulder (which discharges into the Eastbound I-210 drain inlet).

The combined runoff is discharged through a single outfall at the bottom of the embankment adjacent to the Westbound roadway.

3.3.3 Siting Constraints

The siting constraints at this site were as follows:

- Although the distance between the Toe-of-Slope and the Right-of-Way fence is 13 meters, the Concrete Channel is only 2.6 meters away from the Toe-of-Slope. In order to avoid crossing the channel, the BMP facility was located between the Toe-of-Slope and the channel.

- The BMP is located 250 meters away from an existing Chain Link Fence (and gate) at Filmore Street, in a landscaped area. Site access will be provided by constructing a gravel road between the existing gate and the BMP.

- There is not enough fall in elevation between the flow line of the existing outfall and the BMP effluent discharge point to enable the BMP to start at the existing flow line and have a free fall effluent discharge into the channel (i.e., the discharge would be below grade). To correct for this, the runoff will be intercepted slightly up the embankment, providing the necessary elevation differential across the BMP.

- Security of the equipment is a concern at this site. As a result, Chain Link Fence with Barbed Wire will be installed around the perimeter of the BMP facility.

- There are no available sources of power to provide electricity for refrigerated samplers. Therefore, deep cell marine batteries will be used.

4.0 HYDRAULIC ANALYSES

This section will present the hydraulic performance of the BMP Retrofit Pilot Facilities during the expected runoff event from a 1 year, 24 hour storm and a 25 year storm.

4.1 Design Criteria

Technical references used for the hydraulic analysis of the BMP facilities included:

- *Caltrans Highway Design Manual*, California Department of Transportation, 1997.
- *Open Channel Hydraulics*, V.T. Chow, McGraw-Hill, 1959.
- *Water Well Handbook*, K.E. Anderson, Missouri Water Well Association, 1963.
- *Perry's Chemical Engineers Handbook*, R.H. Perry and D.W. Green, McGraw-Hill, 1984.
- *Internal Flow Systems*, D. Miller, BHRA Fluid Engineering, 1978.
- *CDS Technical Manual*, CDS Technologies, Inc., 1999.

4.2 Methodology and Design Procedures

In order to compute the hydraulic profile across the BMP, the retrofit facility was broken down into the following sections, and the Head Loss was estimated across each section:

Section	Description
A	From Roadway to Tee
B	Pipe between Tee and CDS Unit
C	CDS Unit
D	Pipe between CDS Unit and H-Flume
E	H-Flume Structure

The following assumptions were used when computing the various Head Loss values:

- Head loss in pipe between Tee structure and CDS Unit is negligible
- Head loss in pipe between CDS Unit and H-Flume Structure is negligible
- Head at H-Flume Effluent point provided by manufacturer
- Pipe friction factor of 0.07
- Loss coefficient, K, of 0.012 used for 10 degree elbow
- Loss coefficient, K, of 0.045 used for 23 degree elbow
- Loss coefficient, K, of 1.3 used for CMP Tee
- Head loss across CDS Unit provided by manufacturer

- Head loss across litter collection bag estimated with flow through screen calculation:

$$\Delta h = \left(\frac{n}{C^2}\right)\left(\frac{1-\alpha^2}{\alpha^2}\right)\left(\frac{V^2}{2g_c}\right)$$

Where:
 n = Number of screens in series
 α = Frictional free projected area of screen
 V = Superficial velocity ahead of screen
 g_c = Dimension constant
 C = Screen discharge coefficient

- Screen discharge coefficient, C, equal to 1.5 used for Litter Collection Bag where C = $(0.1)N_{Re}^{1/2}$.

4.3 Summary of Results

The hydraulic calculations demonstrate that, during the 25 year event, the open monitoring box will contain the entire runoff and the upstream piping will continue to flow less than full at the I-210 East of Orcas Avenue site. For the I-210 East of Filmore Street BMP, the downstream monitoring box will also contain the flow, but the upstream piping will flow full. Neither site will cause flooding of the I-210 roadway.

A summary of the computed Head Loss for each section is presented in Table 4-1 for the I-210 East of Orcas Ave. site, and in Table 4-2 for the I-210 East of Filmore Street Site.

TABLE 4-1
HYDRAULIC PERFORMANCE – I-210 EAST OF ORCAS

Section	Section Description	Head Loss (m)	
		1 Year	25 Year
A	From Roadway to Tee	3.79	3.70
B	Pipe between Tee and CDS Unit	0.00	0.00
C	CDS Unit	0.09	0.09
D	Pipe between CDS Unit and H-Flume	0.01	0.01
E	H-Flume Structure	0.00	0.00

TABLE 4-2
HYDRAULIC PERFORMANCE – I-210 EAST OF FILMORE

Section	Section Description	Head Loss (m)	
		1 Year	25 Year
A	From Roadway to Tee	3.13	3.05
B	Pipe between Tee and CDS Unit	0.00	0.00
C	CDS Unit	0.09	0.09
D	Pipe between CDS Unit and H-Flume	0.02	0.01
E	H-Flume Structure	0.00	0.00

REFERENCES

K.E. Anderson , *Water Well Handbook*, Missouri Water Well Association, 1963.

Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, prepared for the California Department of Transportation, Environmental Program, May 1997.

California Department of Transportation (Caltrans), *1996 Contract Cost Data, Revision No. 1*, August 1997.

California Department of Transportation (Caltrans), *Average Intensity Duration Curves for District 7*, Los Angeles County Department of Public Works.

California Department of Transportation (Caltrans), *Caltrans Highway Design Manual*, 1997.

California Department of Transportation (Caltrans), *Caltrans Storm Water Quality Handbook*, *Planning and Design Staff Guide*, 1997.

CDS Technologies, Inc., *CDS Technical Manual*, 1999.

V.T. Chow, *Open Channel Hydraulics*, McGraw-Hill, 1959.

The L.K.R. Group, Inc., *Pre-Construction Geotechnical Evaluation Report*, *District 7*, March 9 1998.

D. Miller, *Internal Flow Systems*, BHRA Fluid Engineering, 1978.

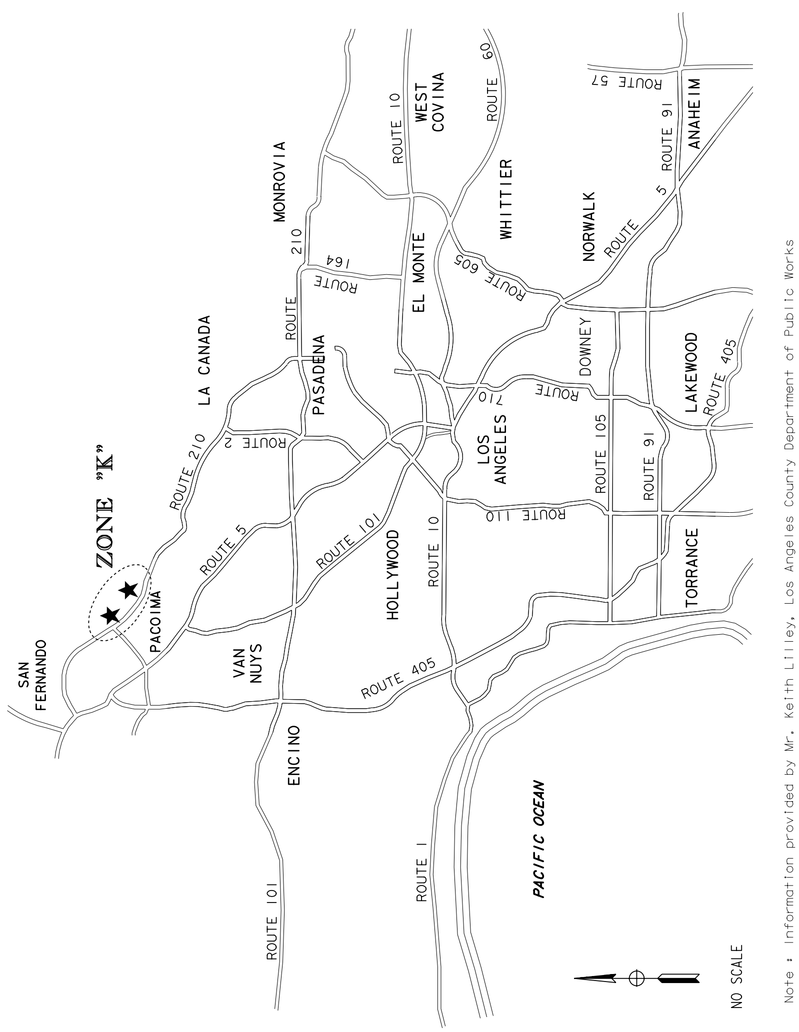
R.H. Perry and D.W. Green, *Perry's Chemical Engineers Handbook*, McGraw-Hill, 1984.

Robert Bein, William Frost and Associates, *Scoping Study, Retrofit Pilot Program*, *Caltrans District 7*, prepared for the California Department of Transportation, Environmental Program, April 28, 1997.

Robert Bein, William Frost and Associates, *BMP Retrofit Pilot Program, Composite Siting Study, District 7*, prepared for the California Department of Transportation, Environmental Program, April 9, 1998.

APPENDIX A

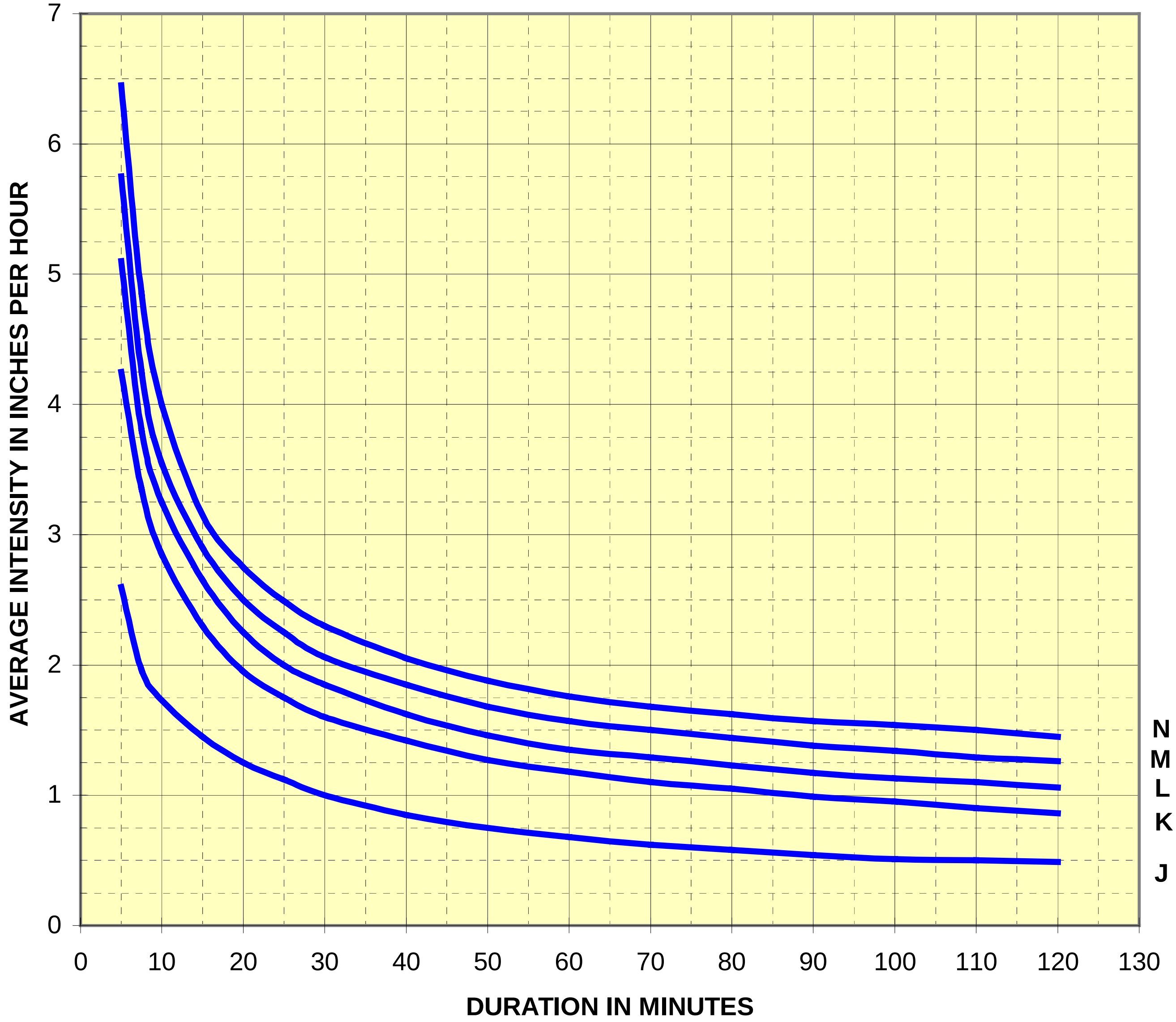
HYDROLOGY CALCULATIONS



BMP SITE RAINFALL ZONES

AVERAGE INTENSITY DURATION CURVES

PROBABLE 25 YEAR FREQUENCY OF RAINFALL FOR DISTRICT 7



HYDROLOGY CALCULATIONS – 1 YEAR EVENT

Site No.	BMP Location	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)	Drain. Area (m^2)	Rainfall Intensity (in/hr)	Q_{peak} (m^3/s)
1	I-210 East of Orcas Ave.	0.95	1	130	5.6	4,416	0.24	0.007
2	I-210 East of Filmore St.	0.95	3	280	5.7	10,200	0.24	0.017

HYDROLOGY CALCULATIONS – 25 YEAR EVENT

Site No.	BMP Location	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)	Drain. Area (m^2)	Rainfall Intensity (in/hr)	Q_{peak} (m^3/s)
1	I-210 East of Orcas Ave.	1.0	1	130	3.8	4,416	2.9	0.09
2	I-210 East of Filmore St.	1.0	3	280	3.8	10,200	2.9	0.21

APPENDIX B

HYDRAULIC CALCULATIONS

Site 1 : I-210 East of Orcas Ave.

Q_{1yr} = 0.0072 (m^3/s)

Inlet Depth (m) = HGL= 337.53

From Freeway to "T" structure, for conservative estimate, calculation assumes full flow

Length (m) = 8.00 (Before elbow)
Length (m) = 4.00 (After elbow)

Depth (m) = 0.07
q = 1.60 =2cos^{-1}((D-y)/D))
Area (m^2) = 0.04 =((q-sin(q))D^2)/8
V (m/s) = 0.18 =Q/A

Friction Hl (m) = 0.00 =(fLV^2)/(2gD)
(f = .07) HGL= 333.75

23^o Elbow Hl (m) = 0.00 =(KV^2)/(2g)
(K = 0.045) **A** HGL= 333.75

Friction Hl (m) = 0.01 =(fLV^2)/(2gD)
(f = .07) **B** HGL= 333.75

Tee Hl (m) = 0.00 =(KV^2)/(2g)
(K = 1.3) **C** HGL= 333.74

From "T" structure to CDS unit **D** HGL= 333.74

Headloss due to pipe friction is negligible
Headloss, m= 0.00

Across the CDS unit **E** HGL= 333.74

Losses (m) due to CDS unit = 0.09
(Worst case as per manufacturer)

From CDS unit to the flume **F** HGL= 333.65

Assume losses in .305 m of .457 diameter pipe are neglible, mesh bag losses below

Pipe Invert El, m	333.62	
Depth (m) =	0.02	(y_c=0.059 m)
q =	0.73	$=2\cos^{-1}((D-y)/D))$
Area (m^2) =	0.02	$=((q-\sin(q))D^2)/8$
V (m/s) =	0.38	=Q/A
Hl (m) =	0.01	$=(1/C2g)(Q/A)^2$
		C = 1.5, mesh coeff.

Losses in the H-Flume transition structure **G** HGL= 333.64

Channel Width, m	0.87
Channel Depth, m	0.12
Flow, cms	0.01
Length, m	2.28
Wetted perimeter, m	1.10
Area (A), sqm	0.10
Hydraulic radius, m	0.09
n=	0.01
$Hl = L(Q*n)^2/(A*R\text{^}(2/3))^2$	0.00

H HGL at Weir 333.64

Head of H-F weir (per manufacturer's specs.), m	0.115
Channel Bottom El, m	333.52

Q_{25yr} = 0.0911 (m^3/s)

Inlet Depth (m) = HGL, EGL = 337.69

From Freeway to "T" structure, for conservative estimate, calculation assumes full flow

Length (m) = 8 (Before elbow)
Length (m) = 4 (After elbow)

Depth (m) = 0.32
q = 3.97 $=2\cos^{-1}((D-y)/D))$
Area (m^2) = 0.12 $=((q-\sin(q))D^2)/8$
V (m/s) = 0.74 =Q/A

Friction Hl (m) = 0.03 $=(fLV^2)/(2gD)$
(f = .07) HGL= 334.12

23^o Elbow Hl (m) = 0.00 $=(KV^2)/(2g)$
(K = 0.045) **A** HGL= 334.08

Friction Hl (m) = 0.02 $=(fLV^2)/(2gD)$
(f = .07) **B** HGL= 334.05

Tee Hl (m) = 0.04 $=(KV^2)/(2g)$
(K = 1.3) **C** HGL= 334.03

From "T" structure to CDS unit **D** HGL= 333.99

Headloss due to pipe friction is negligible
Headloss, m= 0.00

Across the CDS unit **E** HGL= 333.99

Losses (m) due to CDS unit = 0.09
(Worst case head loss as per manufacturer)

From CDS unit to the flume **F** HGL= 333.90

Assume losses in .305 m of .457 diameter pipe are neglible, mesh bag losses below

Pipe Invert El, m	333.62	
Depth (m) =	0.27	(y_c=0.059 m)
q =	3.48	$=2\cos^{-1}((D-y)/D))$
Area (m^2) =	0.09	$=((q-\sin(q))D^2)/8$
V (m/s) =	1.02	=Q/A
Hl (m) =	0.01	$=(1/C2g)(Q/A)^2$ A = bag open area
		C = 1.5, mesh coeff.

Losses in the H-Flume transition structure

G HGL= 333.89

Channel Width, m	0.87
Channel Depth, m	0.21
Flow, cms	0.09
Length, m	2.28
Wetted perimeter, m	1.29
Area (A), sqm	0.18
Hydraulic radius, m	0.14
n=	0.01
$Hl = L(Q^*n)^2/(A^*R^\wedge(2/3))^2$	0.00

H HGL at Weir 333.89

Head of H-F weir (per manufacturer's specs.), m	0.37
Channel Bottom El, m	333.52

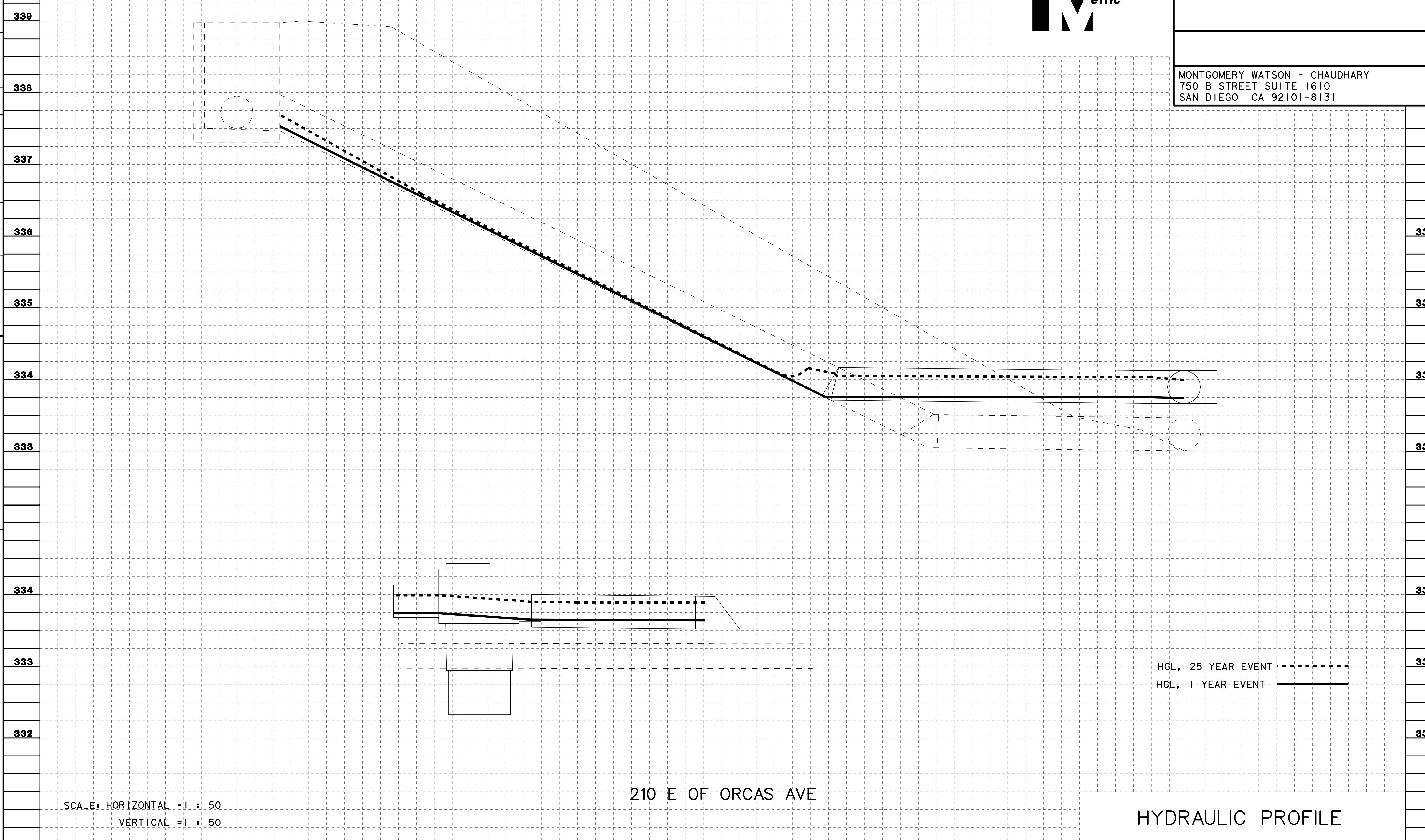
DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	210	10.4, 13.9	1	2

Metric

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

DATE 7/99	REVISED BY
7/99	DATE REVISED
CALCULATED/ DESIGNED BY	CHECKED BY

PROJECT ENGINEER
GARY FRIEDMAN



SCALE: HORIZONTAL = 1 : 50
VERTICAL = 1 : 50

210 E OF ORCAS AVE

HYDRAULIC PROFILE

Station	
m^3 Exc	
Emb	

LAST REVISION DATE PLOTTED => 07-JUN-2000

Site 2 : I-210 East of Filmore St.

Q_{1yr} = 0.0165 (m^3/s)

Inlet Depth (m) = HGL= 364.26

From Freeway to "T" structure, for conservative estimate, calculation assumes full flow

Length (m) = 8.00 (Before elbow)
Length (m) = 4.00 (After elbow)

Depth (m) = 0.15
q = 2.40 $=2\cos^{-1}((D-y)/D))$
Area (m^2) = 0.06 $=((q-\sin(q))D^2)/8$
V (m/s) = 0.27 =Q/A

Friction Hl (m) = 0.00 $=(fLV^2)/(2gD)$
(f = .07) HGL= 361.14

10^o Elbow Hl (m) = 0.00 $=(KV^2)/(2g)$
(K = 0.012) **A** HGL= 361.14

Friction Hl (m) = 0.01 $=(fLV^2)/(2gD)$
(f = .07) **B** HGL= 361.14

Tee Hl (m) = 0.00 $=(KV^2)/(2g)$
(K = 1.3) **C** HGL= 361.13

From "T" structure to CDS unit **D** HGL= 361.13

Headloss due to pipe friction is negligible
Headloss, m= 0.00

Across the CDS unit **E** HGL= 361.13

Losses (m) due to CDS unit = 0.09
(Worst case as per manufacturer)

From CDS unit to the flume — **F** — HGL= 361.04

Assume losses in .305 m of .457 diameter pipe are neglible, mesh bag losses below

Pipe Invert El, m	360.94	
Depth (m) =	0.08	(y_c=0.048 m)
q =	1.25	$=2\cos^{-1}((D-y)/D))$
Area (m^2) =	0.12	$=((q-\sin(q))D^2)/8$
V (m/s) =	0.14	=Q/A
Hl (m) =	0.01	$=(1/C2g)(Q/A)^2$
		C = 1.5, mesh coeff.

Losses in the H-Flume transition structure — **G** — HGL= 361.02

Channel Width, m	1.16
Channel Depth, m	0.17
Flow, cms	0.02
Length, m	2.28
Wetted perimeter, m	1.49
Area (A), sqm	0.19
Hydraulic radius, m	0.13
n=	0.01
Hl $=L(Q*n)^2/(A*R^{\wedge}(2/3))^2$	0.00

H — HGL at Weir 361.02

Head of H-F weir (per manufacturer's specs.), m	0.16
Channel Bottom El, m	360.86

0.2104 (m^3/s)

Inlet Depth (m) = HGL, EGL = 364.53

From Freeway to "T" structure, for conservative estimate, calculation assumes full flow

Length (m) = 8.00 (Before elbow)
Length (m) = 4.00 (After elbow)

Depth (m) = 0.46
q = 6.28 $=2\cos^{-1}((D-y)/D))$
Area (m^2) = 0.16 $=((q-\sin(q))D^2)/8$
V (m/s) = 1.31 =Q/A

Friction Hl (m) = 0.03 $=(fLV^2)/(2gD)$
(f = .07) HGL= 361.70

10^o Elbow Hl (m) = 0.00 $=(KV^2)/(2g)$
(K = 0.012) **A** HGL= 361.67

Friction Hl (m) = 0.04 $=(fLV^2)/(2gD)$
(f = .07) **B** HGL= 361.63

Tee Hl (m) = 0.11 $=(KV^2)/(2g)$
(K = 1.3) **C** HGL= 361.59

From "T" structure to CDS unit **D** HGL= 361.48

Headloss due to pipe friction is negligible
Headloss, m= 0.00

Across the CDS unit **E** HGL= 361.48

Losses (m) due to CDS unit = 0.09
(Worst case head loss as per manufacturer)

From CDS unit to the flume **F** HGL= 361.39

Assume losses in .305 m of .457 diameter pipe are neglible, mesh bag losses below

Pipe Invert El, m	360.94	
Depth (m) =	0.44	
q =	3.15	$=2\cos^{-1}((D-y)/D))$
Area (m^2) =	0.29	$=((q-\sin(q))D^2)/8$
V (m/s) =	0.72	=Q/A
Hl (m) =	0.01	$=(1/C2g)(Q/A)^2$
		C = 1.5, mesh coeff.

Losses in the H-Flume transition structure

G HGL= 361.38

Channel Width, m	1.16
Channel Depth, m	0.17
Flow, cms	0.21
Length, m	2.28
Wetted perimeter, m	1.49
Area (A), sqm	0.19
Hydraulic radius, m	0.13
n=	0.01
Hl $=L(Q*n)^2/(A*R\hat{}(2/3))^2$	0.00

H HGL at Weir 361.37

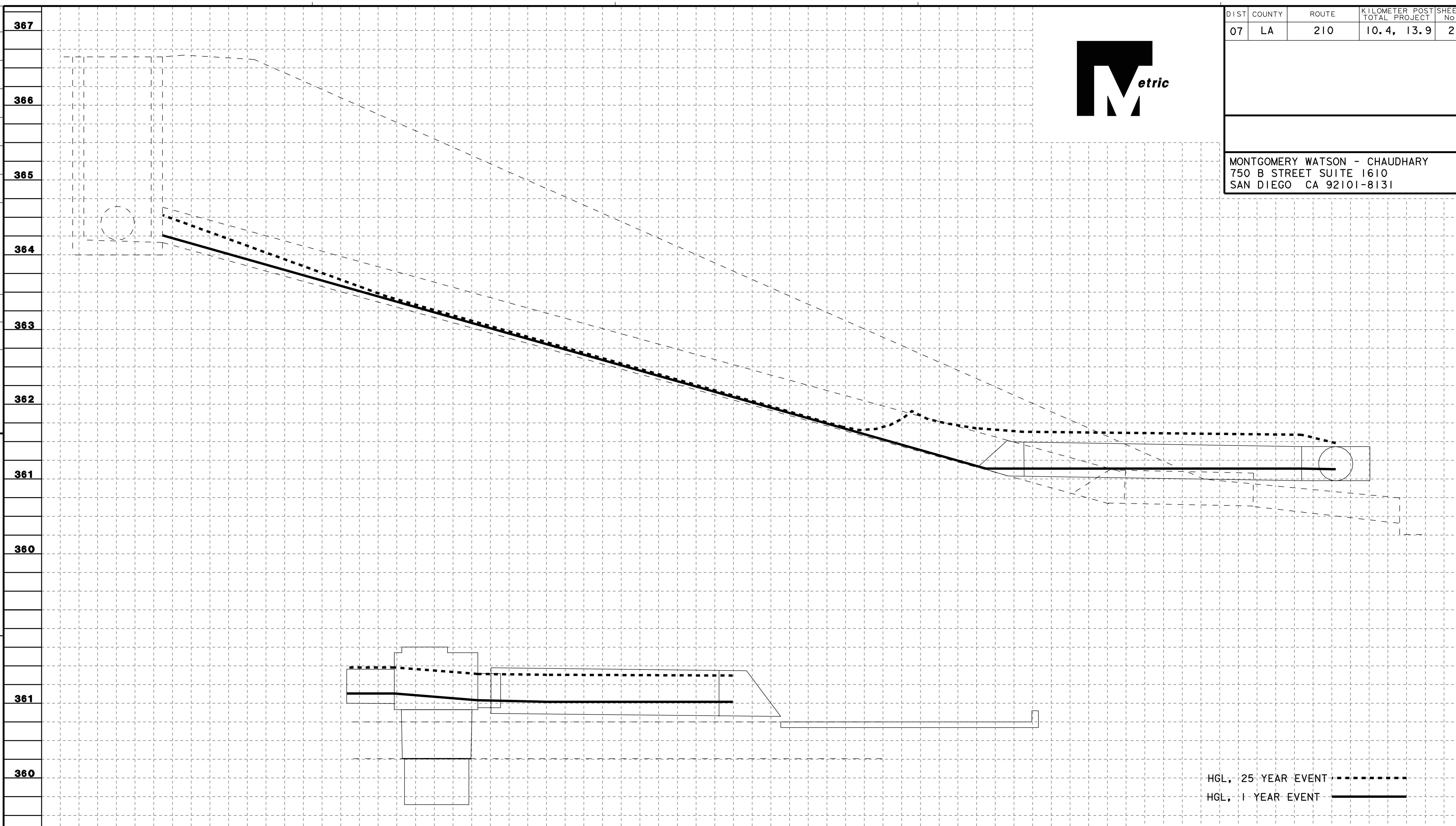
Head of H-F weir (per manufacturer's specs.), m	0.51
Channel Bottom El, m	360.86

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
07	LA	210	10.4, 13.9	2	2

Metric

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

DATE 7/99 REVISED BY
7/99 DATE REVISED
CALCULATED/DESIGNED BY
CHECKED BY
PROJECT ENGINEER
GARY FRIEDMAN



SCALE: HORIZONTAL = 1 : 50
VERTICAL = 1 : 50

210 E OF FILMORE ST

HYDRAULIC PROFILE

Station	
m^3	Exc
	Emb

LAST REVISION 00-00-00 DATE PLOTTED => 07-JUN-2000

APPENDIX C

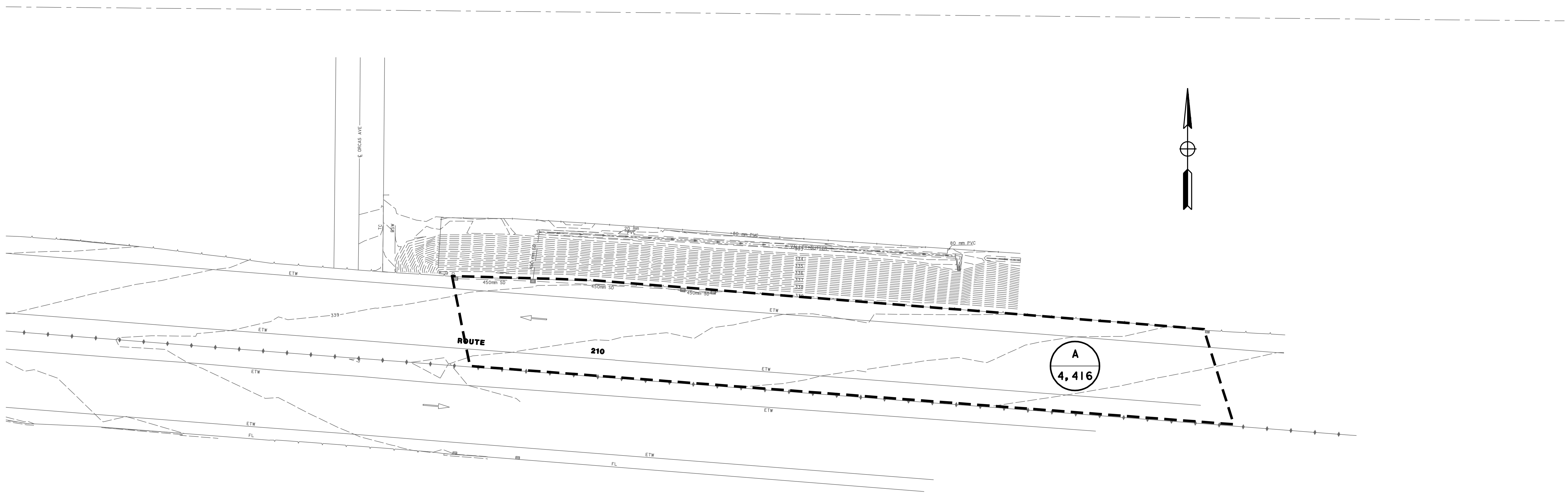
HYDROLOGY MAPS

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	210	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

WATERSHED/SUBAREA

A / 100 — AREA DESIGNATION / SUBAREA AREA (M^2)

DRAINAGE FACILITY

SITE 1: I-210 EAST OF ORCAS AVE.

ALL DIMENSIONS ARE IN
METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

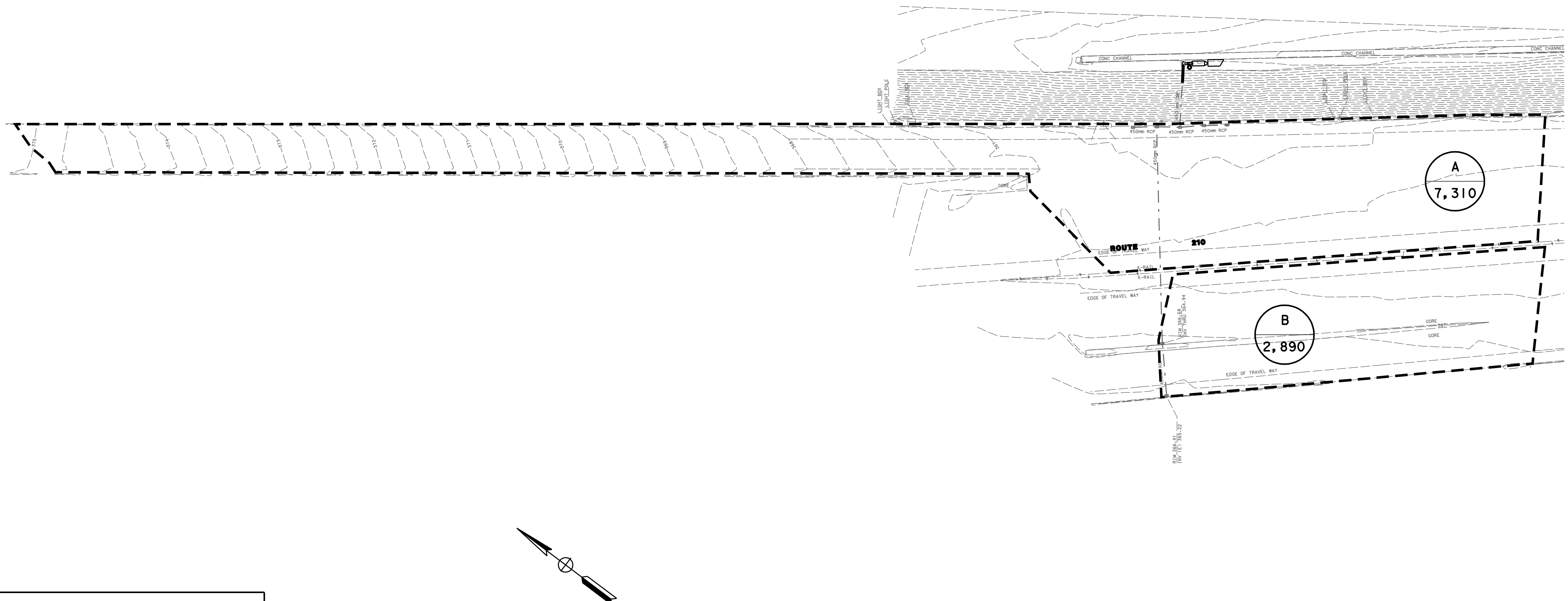
SCALE 1:500

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	210	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

- - - WATERSHED/SUBAREA

A / 100 AREA DESIGNATION SUBAREA AREA (M^2)

—— DRAINAGE FACILITY

SITE 2 : I-210 EAST OF FILMORE ST

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:500

APPENDIX D

ENGINEERING COST ESTIMATE

Engineer's Estimate of Construction

Item No.	Unit of Measure	Item Description	I-210 E of Orcas Est. Qty	I-210 E of Orcas Total Cost	I-210 E of Filmore Est. Qty	I-210 E of Filmore Total Cost
1	EA	10' CHAIN LINK GATE (TYPE CL-6)	1.00	1,210.00		
2	EA	4' CHAIN LINK GATE (TYPE CL-8)	1.00	1,040.00	1.00	1,040.00
3	EA	450 MM 10° CMP ELBOW			1.00	210.00
4	EA	450 MM 23° CMP ELBOW	1.00	210.00		
5	M	450 MM CMP PIPE	4.00	2,240.00	4.00	2,240.00
6	EA	450 MM CMP TEE	1.00	870.00	1.00	870.00
7	EA	ANCHOR ASSEMBLY, ALT. B	2.00	520.00	2.00	520.00
8	M	CHAIN LINK FENCE (TYPE CL-8)	30.00	5,100.00	30.00	5,100.00
9	M3	CLASS 2 AGGREGATE BASE	4.00	320.00	50.00	4,000.00
10	LS	CLEARING & GRUBBING	0.40	1,736.00	0.60	2,604.00
11	EA	CMP COUPLING	3.00	510.00	3.00	510.00
12	M2	EROSION CONTROL (TYPE D)	150.00	937.50	1,000.00	6,250.00
13	M3	IMPORTED BORROW	4	360.00	4	360.00
14	EA	INSTALL 457 FRP FLUME STRUCTURE	1.00	2,000.00		
15	EA	INSTALL 610 FRP FLUME STRUCTURE			1.00	3,000.00
16	EA	INSTALL CDS UNIT	1.00	9,000.00	1.00	9,000.00
17	EA	LITTER BAG	1.00	260.00	1.00	260.00
18	M3	MINOR CONCRETE	2.32	5,104.00	1.98	4,356.00
19	EA	NEOPRENE COUPLING	1.00	170.00	1.00	170.00
20	EA	REMOVE APRON			1.00	870.00
21	M	REMOVE CHAIN LINK FENCE	1.40	196.00		
22	EA	REMOVE CHAIN LINK GATE	1.00	340.00		
23	EA	REMOVE ELBOW	2.00	1,380.00	1.00	690.00
24	EA	REMOVE FLARED END SECTION			1.00	600.00
25	EA	REMOVE PIPE	2.00	3,460.00	1.00	1,730.00
26	M	REMOVE V-DITCH	4.50	990.00		
27	M3	ROCK SLOPE PROTECTION			1.00	430.00
28	M3	SAND BACKFILL	0.70	154.00	0.70	154.00
29	M3	SAND BEDDING	0.20	44.00	0.20	44.00
	TOTAL			**$38,151.50**		**$45,008.00**